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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 9 MISSION
5-DAY REPORT

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APOLLO 9 MISSION

5-DAY REPORT

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS
March 1969

SUMMARY

Apollo 9 was the first manned flight involving the lunar module. The crew were James A. McDivitt, Commander; David R. Scott, Command Module Pilot; and Russell L. Schweickart, Lunar Module Pilot.

The launch, which had been scheduled for February 28, was postponed for 3 days because all three crewmen had upper respiratory infection. The space vehicle was launched from Kennedy Space Center, Florida, at 11:00:00 a.m. e.s.t., March 3, 1969. Following a nominal launch phase, the spacecraft and S-IVB combination was inserted into an orbit of 102.3 by 103.9 nautical miles.

After post-insertion checkout was completed, the command and service modules were separated from the S-IVB, transposed, and docked with the lunar module. The docked spacecraft were separated from the S-IVB at 4:08:05. Four service propulsion firings lasting 5.1, 110.0, 281.6, and 28.2 seconds, were made while the spacecraft remained docked.

At approximately 43.5 hours, the Lunar Module Pilot and the Commander transferred to the lunar module. A 369.7-second firing of the lunar module descent propulsion system was initiated about 6 hours later; the two crewmen then returned to the command module for the fifth service propulsion firing, which lasted 43.3 seconds.

At approximately 70 hours, the Lunar Module Pilot and the Commander again transferred for the Lunar Module Pilot's 37-minute extravehicular activity.

At about 89 hours, the Commander and the Lunar Module Pilot returned to the lunar module for the third time to perform the rendezvous. The lunar module primary guidance system was used to conduct the rendezvous with back-up calculations being made by the command module computer. The phasing and insertion maneuvers were performed using the descent propulsion system to set-up the rendezvous. The ascent and descent stages were separated, followed by a reaction control coelliptic sequence initiation maneuver. The ascent propulsion system was fired to establish the constant delta height. The terminal phase of the rendezvous began on time, and the spacecraft were again docked at about 99 hours. The ascent stage was jettisoned about 2-1/2 hours later. Shortly after, the ascent propulsion system was fired to propellant depletion. The firing lasted 350 seconds and resulted in an orbit of 3747 by 124.5 nautical miles.

The sixth service propulsion firing, to lower apogee, was delayed because the +X translation to precede the maneuver was not programmed properly. However, the maneuver was rescheduled and successfully completed in the next revolution.

During the last three days, a 25-second seventh service propulsion firing was made to raise the apogee, and a multispectral photography experiment and landmark tracking were accomplished.

Unfavorable weather in the planned landing area caused the deorbit maneuver to be delayed for one revolution. The command module landed in the Atlantic Ocean near the target of 23 degrees 15 minutes north latitude, 68 degrees west longitude, as determined from the onboard computer solution. The total flight duration was 241 hours, 53 seconds.

All spacecraft systems performed essentially as planned. Thermal characteristics of both spacecraft varied within acceptable limits. Consumables usage was maintained at acceptable levels. Communications quality was generally satisfactory with television transmissions from the lunar module on two occasions.

INTRODUCTION

This report is based on an evaluation of preliminary data, and the stated values are subject to change in later reports. All times are referenced to range zero, the integral second before lift-off; range zero was 16:00:00 G.m.t., March 3, 1969. A sequence of significant mission events is presented in table I. Only the most significant systems information is presented in the appropriate sections.

EXTRAVEHICULAR ACTIVITY

Extravehicular activity, planned for the third day, was reduced from 2 hours 15 minutes to about 1 hour of depressurized lunar module activity. This change was made because the Lunar Module Pilot experienced a minor inflight illness during the first 2 days of the mission.

Preparation for extravehicular activity began at approximately 71 hours. The Commander and the Lunar Module Pilot were in the lunar module and the Command Module Pilot in the command module. At approximately 73 hours, after donning the portable life support and oxygen purge systems, the Lunar Module Pilot egressed through the forward hatch and moved to the external foot restraints on the platform. During this time, the command module was depressurized, and the side hatch was opened. Thermal sample retrieval was photographically recorded with the sequence cameras. The Lunar Module Pilot used the handrails to evaluate body control and transfer techniques. Ingress was completed at about 74 hours. Both hatches were then secured and the vehicles repressurized. The portable life support system was successfully recharged with oxygen and water.

The lithium hydroxide cartridge from the system was returned to the command module for postflight metabolic analysis.

The repressurization cycles for both vehicles were nominal, and post-activity procedures were followed without difficulty.

Heart and metabolic rates for the Lunar Module Pilot during the extravehicular activity were very low, about 61 to 88 beats/minute and 500 Btu/hr, respectively.

RENDEZVOUS

The Commander and the Lunar Module Pilot transferred to the lunar module on the fifth day for the rendezvous. The rendezvous exercise began on schedule with a 5 ft/sec separation maneuver using the service module reaction control system.

A phasing maneuver of 90.5 ft/sec was performed with the lunar module descent propulsion system, about 2.8 n. mi. from the command module. At approximately 12 n. mi. above and 27 n. mi. behind the command and service modules, the descent propulsion system was used to impart a 43.1-ft/sec insertion velocity to the lunar module. At a range of 75 n. mi. from the command and service modules, the ascent and descent stages of the lunar module were separated, and a coelliptic sequence initiation maneuver of 40.0 ft/sec was made with the lunar module reaction control system. At approximately 10 n. mi. below and 78 n. mi. behind the command and service modules, the constant delta height maneuver was performed with the ascent propulsion system imparting a velocity change of 41.5 ft/sec. The terminal phase began on time with a 22.3-ft/sec lunar module reaction control system maneuver.

Braking maneuvers were conducted on schedule, and station-keeping was maintained at a distance of 100 feet so that photographs could be taken from both vehicles. Docking was successfully completed at about 99 hours. Problems were experienced in using the crewman optical alignment sight in both vehicles during docking. The combination of a bright command module, a dimly lighted command module target, and a relatively dim reticle in the alignment sight made lunar module docking a difficult task. Propellant usage by the lunar module reaction control system during the rendezvous was about 35 percent less than predicted.

Lunar module rendezvous navigation and maneuver targeting using both the primary and the backup guidance systems were satisfactory. Radar data were successfully used, both automatically by the primary system and through manual insertion in the abort guidance system, to correct rendezvous state vectors. Maneuver solutions from both onboard systems and from ground computations appeared to correlate closely. The crew selected the primary system solutions for all maneuvers through the first midcourse correction performed after terminal phase initiation.

Rendezvous navigation and mirror-image targeting in the command module were performed satisfactorily; however, loss of the lunar module tracking light prevented sextant measurements from the command module when both vehicles were in darkness. Preliminary data indicate that command module maneuver calculations for terminal phase initiation were satisfactory.

TRAJECTORY

The spacecraft/S-IVB combination was inserted into earth orbit at 0:11:14.7 after a normal launch phase. At insertion, the space-fixed velocity was 25 567 ft/sec, flight-path angle was 0.002 degree, and altitude was 103.4 n. mi. The resulting orbital elements and maneuver parameters are given in table II for all engine firings.

Four service propulsion system maneuvers were performed prior to the first docked descent engine firing. Each of the first three service propulsion maneuvers were made without requiring a +X translation to settle propellants. The fourth service propulsion maneuver was preceded by an 18-second +X translation made with the service module reaction control system. None of the orbits resulting from these maneuvers differed by more than 2.3 n. mi. from the planned conditions.

The fifth docked service propulsion maneuver resulted in the perigee being approximately 5 n. mi. less than planned causing the rendezvous to be initiated 4 minutes earlier. Small cutoff errors of this magnitude were expected, and real-time trajectory planning for both rendezvous and deorbit was conducted to accommodate minor adjustments in the initiation times and velocity increments. In this regard, out-of-plane components were added during the flight to certain preplanned maneuvers to provide substantial reduction in spacecraft weight without significantly changing the orbital parameters for subsequent maneuvers.

The trajectory aspects of the rendezvous exercise have been previously discussed.

After the ascent stage jettison, a 3-ft/sec separation maneuver was performed by the service module reaction control system. The ascent engine was then fired to propellant depletion.

The sixth service propulsion maneuver was delayed one revolution and completed nominally.

The deorbit maneuver was made over Hawaii during revolution 152, and command module/service module separation was performed. The entry conditions at entry interface were 25 897 ft/sec in velocity and -1.8 degrees in flight-path angle. The command module landed at 241:00:53 near 23 degrees 15 minutes north latitude and 68 degrees west longitude (see Mission Support Performance, Recovery).

COMMUNICATIONS

Communications were generally satisfactory. Good quality real-time and dumped telemetry data were received. Voice quality was good throughout the rendezvous and during most of the other mission phases. Television was received during two transmission periods from the lunar module.

During launch, the S-band uplink phase lock was lost from 0:05:06 to 0:06:00. During the uplink loss and subsequent reacquisition attempts, the automatic transfer of downlink signal sources within the spacecraft transponder caused intermittent loss of downlink lock and telemetry synchronization.

S-band voice from the lunar module was not received at the Mission Control Center during the first television transmission. The S-band voice was received at the Merritt Island station, however, and it is suspected that transmission to the Mission Control Center was inhibited by a voice-operated amplifier within the Merritt Island station.

Good quality voice transmission was received from each of the crewmen during the extravehicular activity; however, the crew did not receive uplink voice transmissions through the Guaymas, Texas, Merritt Island, Bermuda, and USNS Vanguard stations. Incorrect configuration at all of the affected stations, except Bermuda, resulted in transmissions using only the S-band uplink. Reception was inhibited because the spacecraft S-band volume control settings were set at full decrease as specified in the checklist. Transmission from Bermuda was made during periods of intervehicular communication, when the spacecraft VHF receivers are normally in a captured configuration.

Verification of the commands transmitted between 109:21:50 and 118:46:53 was not detected by the ground stations, but available data confirm that the commands were properly encoded and transmitted.

COMMAND AND SERVICE MODULE SYSTEMS PERFORMANCE

Structural and Mechanical Systems

At lift-off, measured peak winds at both the 60-foot level and the region of high dynamic pressure were below the established limits. During the launch phase, accelerations measured in the command module were nominal and similar to those measured during the Apollo 8 mission.

All hardware in the mechanical systems performed satisfactorily, and only two discrepancies were noted. Both were associated with docking and have been duplicated in ground testing.

During initial undocking, the Command Module Pilot activated the probe-extend switch, and the vehicles began to separate, indicating release of the probe-extend latch. However, the vehicles did not physically separate because the switch was not held in the undock position long enough and the probe-capture latches remained in the locked configuration. Recycling of the switch completed the probe extension, and normal undocking was achieved.

Prior to the lunar module docking maneuver, the Command Module Pilot placed the probe-extend/release switch in the retract position in preparation for docking. With the switch in this position, an indication showed the probe was not in the correct position for docking. Switching through the extend/retract cycle produced the normal indication.

Electrical Power

Batteries.- The entry and pyrotechnic batteries performed satisfactorily. Battery A received one complete and three partial recharges, and battery B received four partial recharges. Battery C was not recharged. The battery recharging was adequate to support mission requirements, although the charging time for battery B was longer than expected. The charge remaining in the batteries at command module/service module separation was estimated to be 39.0, 32.4, and 38.9 A-h for batteries A, B, and C, respectively, for a total of 110.3 A-h.

Fuel cells and cryogenic storage.- Operation of the fuel cells and cryogenic storage system was satisfactory. Servicing and top-off of cryogenic hydrogen and oxygen before lift-off were accomplished, and fuel cell start-up was normal.

Operation of the cryogenic oxygen storage system was normal. A caution-and-warning alarm for the hydrogen system was activated first at approximately 5 hours and several times thereafter when the pressure in tank 1 fell below the alarm trip level of 227 psi.

At approximately 94 hours, the heaters in the hydrogen tanks failed to come on automatically. At 101 hours, the automatic system recovered and increased the pressure in both tanks to above the pressure where automatic cutoff should occur. The heater system was manually turned off at 106 hours. Pressure control was maintained by manual control of fan operation for the remainder of the mission.

Cryogenic usage rates were within 2 percent of predicted values, and quantity balancing in both systems was satisfactorily maintained.

At 62 hours, the condenser exit temperature of fuel cell 2 dropped to approximately 150° F (normal is 155° to 165° F). At 90.5 hours, the temperature peaked at 175° F for the first of several excursions out of normal operating tolerances; however, the parameter recovered at about 191 hours and remained within normal limits thereafter.

The fuel cells generated 450 kWh, 15 000 A-h, and 350 pounds of water during the mission. Total hydrogen and oxygen usages were 42 and 330 pounds, respectively.

Communications

Management and performance of the communications systems were good throughout the flight and during the recovery operation. Most of the omnidirectional antenna switching, selection of high- and low-bit-rate telemetry, and record and playback of data storage equipment were accomplished by real-time command.

From approximately 109 to 119 hours, ground stations were unable to accomplish multiple commands to the spacecraft; however, command capability was restored after the crew cycled the uplink command switch.

The S-band omnidirectional antennas were used throughout the mission, except for a short period during the ninth day when the automatic reacquisition mode of the high-gain antenna was exercised over the Carnarvon and Hawaii stations.

Instrumentation

The instrumentation system provided adequate support for the mission. Lunar module telemetry data were successfully transmitted to the command module over the VHF link and were then recorded and dumped through command module S-band equipment.

The central timing equipment experienced a reset to zero at approximately 168 hours and was subsequently corrected through the command link. The timing equipment operated properly thereafter.

Display of data from the helium-tank pressure transducer in the service propulsion system was lost at lift-off, but the redundant transducer provided satisfactory data.

At about 23 hours, the oxygen flow rate indication for fuel cell 3 displayed a higher-than-expected value but returned to normal at 27 hours 30 minutes.

Controls and Displays

Several master caution-and-warning alarms occurred during the mission. Certain of these alarms were appropriate for the conditions that existed, including those associated with gaging system operation for service propulsion maneuvers 3 and 7. Other alarms occurred, once at command and service module docking and twice during the deorbit maneuver, which appear to be unrelated to system conditions and are not explained at this time.

Guidance, Navigation, and Control

All guidance, navigation, and control functions were performed satisfactorily. At insertion, the differences between the onboard and the ground-calculated apogee and perigee altitudes were larger than normal. The cause of these differences was isolated to a change in X-axis accelerometer bias in the final countdown period. This bias change caused a misalignment during prelaunch gyrocompassing, as well as a direct downrange velocity error during ascent. The bias compensation was updated in flight and remained stable for the remainder of the mission. Other measurable inertial parameters were also stable throughout the mission. The inertial measurement unit was aligned optically several times with excellent results. The crew reported some difficulty in the use of the scanning telescope, in that it tended to stop momentarily at times when rotating about the shaft axis. On other occasions, the unit stuck such that manipulation using the universal tool was required before operation could be resumed. The sextant was not affected and remained fully operational throughout the mission.

Eight service propulsion maneuvers were performed, and the results were consistent with preflight predictions. All maneuvers except one were controlled by the digital autopilot. Manual takeover was accomplished during the third maneuver, and manual thrust vector control using the rate mode of the stabilization and control system was satisfactory.

Stroking tests were performed during the second and third service propulsion maneuvers. These tests involved a preprogrammed sequence of engine gimbal motions that had been selected to excite structural bending of the docked vehicles. Results were as predicted.

A number of landmark tracking exercises were performed to demonstrate the yaw/roll control technique. Although the telescope drive problem caused some difficulty, the technique was satisfactory.

The entry monitor system performed properly while monitoring all service propulsion maneuvers. Navigation and backup targeting during rendezvous were performed successfully. Primary guidance and control performance during entry was nominal.

Reaction Control System

All reaction control system parameters were normal. The command module reaction control system performed normally during entry.

The thermal control system in the service module reaction control system maintained package temperatures within the normal range of 120° to 140° F, except during times of frequent engine usage. The command module engine temperatures remained above the 28° F lower limit and the heaters were not required. A total of 813 pounds of service module propellants were used during the mission, with 225 pounds being consumed during undocked operations with the lunar module.

During transposition and docking, translation capability to the left did not exist because all normally open propellant isolation valves on quad C and secondary propellant tank isolation valves on quad D were closed. Normal system operation was returned when the crew reopened these valves and no similar discrepancies occurred during the remainder of the mission.

Service Propulsion

Eight service propulsion maneuvers were accomplished for a total firing duration of 506 seconds. The actual firing times and velocity increments are summarized in table II. With the exception of the propellant utilization and gaging system, the service propulsion system performed nominally throughout the flight.

Operation of the propellant utilization and gaging system was satisfactory until propellant had been depleted from the storage tanks during the third service propulsion maneuver. After depletion of these tanks, a bias in the indicated oxidizer quantity caused several caution-and-warning signals during this maneuver. The gaging system was disabled for all remaining maneuvers until a special gaging test performed during the seventh firing. A non-firing test had indicated satisfactory operation of all servo-motor loops and the caution and warning system, and the gaging system was reactivated for the seventh maneuver. Results of this firing indicate that the oxidizer quantity indication was biased by about 3 percent. The bias discrepancy has been isolated to the primary gaging system of the oxidizer storage tank.

Environmental Control System

Performance of the environmental control system was satisfactory. Pressurization of the lunar module was accomplished by increasing the command module cabin pressure to 5.8 psia and then dumping the stored gas into the lunar module.

The cabin fans were off for most of the mission. On the seventh day, cabin fan 1 was found to be inoperative.

Crew Provisions

Crew provisions, including the space-suit were adequate. The crew experienced some difficulty maneuvering within the command module cabin and transferring to the lunar module because of a stiffness in the oxygen umbilicals.

LUNAR MODULE SYSTEMS PERFORMANCE

Structural and Mechanical Systems

Accelerations measured on the lunar module during first-stage boost prior to cutoff compared well with values obtained during Apollo 8. The acceleration responses in the X and Z axes immediately after first-stage engine cutoff were higher than those on previous missions. However, the loads resulting from the worst combination of the lateral and axial accelerations were within the lunar module structural capability.

Thermal Control

The passive and active thermal control systems performed nominally. All data indicate acceptable temperatures, and no significant thermal problems were evident during the mission. The lunar module insulation performed satisfactorily, as evidenced by a drop of only 2° F in bulk propellant temperatures during the first 42-hour period of dormant operation and by the nominal 66° to 72° F range of propellant temperatures for the mission.

Electrical Power

The descent, ascent, and pyrotechnic batteries performed satisfactorily. The descent batteries supplied 1056 A-h of a nominal total capacity of 1600 A-h. The ascent batteries had delivered 368 A-h at the completion of the ascent engine firing to depletion from a nominal total capacity of 620 A-h. Paralleling of the descent and ascent batteries was demonstrated, and all switchovers were accomplished as required. The dc bus voltage was maintained above 28.9 V dc, and the maximum observed load was 103 amperes. Both inverters performed satisfactorily.

Communications

The communication system adequately supported the mission. During the S-band backup voice check at about 50.7 hours, air-to-ground transmissions were not received. The crew had configured for continuous intercommunications only; therefore, attempted transmissions without activating the required push-to-talk switch were unsuccessful. The only systems problem occurred at approximately 88 hours, when activation of the Lunar Module Pilot's push-to-talk switches on the umbilical and hand controller failed to transmit downlink voice. It cannot be verified whether or not these switches were checked for proper operation after this discrepancy occurred. The lunar configuration camera was used for the first time, and resulted in two television transmissions of good quality.

Instrumentation

The performance of the operational instrumentation was satisfactory with only minor exceptions. The displayed values of supercritical helium pressure were intermittent, but an independent telemetry measurement for this pressure was nominal. The two descent-fuel-tank temperature measurements indicated random positive shifts of approximately 5° F. The suit-disconnect-valve measurement for the Lunar Module Pilot was intermittent, but proper valve operation was verified by the crew. The water quantity measuring device in ascent tank 1 indicated abnormally high water usage. The pressure switch measurement for thruster 4 (up) in the reaction control system was inoperative from the initial hot-firing until just prior to docking, after which time it remained intermittent. A low-level propellant warning occurred after the last descent engine firing; however, both fuel and oxidizer panel indicators displayed normal quantities. A caution-and-warning signal for the abort guidance system occurred at approximately 90 hours and was confirmed by telemetry data. The system was then checked by the crew and found to be normal.

The development flight instrumentation, including the VHF, PCM, and C-band transponder links, operated satisfactorily. One of the temperature measurements in the descent stage engine cavity was inoperative from 2 minutes before lift-off through the first descent engine firing, but afterwards, the measurement performed satisfactorily. The yaw vibration measurement on the navigation base was inoperative throughout the flight. The measurements for oxidizer interface pressure and strut-4 strain for the descent engine operated improperly during the first descent propulsion system maneuver, but performed satisfactorily thereafter.

Tracking Light

The tracking light operated normally until ascent stage/descent stage separation, after which it was inoperative.

Radar

The landing radar self-test was accomplished successfully. The landing radar was monitored during the descent engine firing, and no indications of lock-up were observed. The rendezvous radar was exercised over a range of 260 feet to approximately 100 n. mi., and all data appear to be within acceptable limits.

Guidance and Control

Guidance and control system performance was satisfactory throughout the mission. While docked, the primary guidance system was aligned to a set of gimbal angles calculated on the ground from spacecraft gimbal data; while undocked, the system was aligned with the alignment optical telescope. Both methods appear to provide the required accuracy. Gyro drift data and accelerometer bias measurements indicated stable inertial component performance.

The abort guidance system was aligned, calibrated, and initialized with the primary system a number of times with nominal results. Gyro and accelerometer errors were very small and stable. Initial attempts at abort system state vector initialization failed because of procedural problems. The initialization failures occurred with the telemetry system in the low-bit-rate mode when no computer information was present. All initialization attempts during high-bit-rate operation were successful.

An abort guidance system warning alarm occurred during the second power-up sequence. The alarm is normally caused by either a self-test failure or by an out-of-limits condition, and indications are that a malfunction occurred in the alarm circuit, rather than the abort guidance.

All translation maneuvers were nominal. The primary system digital autopilot controlled the docked descent firing, the ascent engine firing to depletion, and all but one of the rendezvous maneuvers. The abort guidance system controlled the descent engine operation during the phasing maneuver.

All significant primary and secondary attitude control modes were exercised.

Reaction Control

Performance of the reaction control system in all modes was satisfactory. Operation of the propellant feed system was nominal.

Propellant consumption through lunar module docking was about 35 percent less than predicted. Cluster temperatures were maintained within expected ranges.

Descent Propulsion

The descent propulsion system was operated three times. The first firing, which lasted 370 seconds, was made while the spacecraft were docked. A discrepancy was noted in the supercritical helium pressurization system, in which helium flow appeared to be blocked until approximately 30 seconds after ignition.

The last two descent engine firings were accomplished as a part of rendezvous. Some roughness was experienced during a momentary pause at the 20 percent point while throttling from 10 to 40 percent thrust during the second firing. A low-level warning light was activated during the last firing with the primary gaging probes indicating normal quantities in all four propellant tanks.

Immediately after the first descent engine firing, the supercritical helium tank pressure continually decreased. Data indicate a leak occurred upstream of the external heat exchanger.

Ascent Propulsion

Ascent propulsion system parameters during the coast period from launch to the first ascent engine firing were nominal. Pressurization was accomplished normally prior to rendezvous, and the 2.9-second initial firing was successfully performed. The second engine firing of 350 seconds was successfully completed, achieving oxidizer depletion as planned. Ascent propulsion system operation was normal during this firing, except for apparent loss of the primary regulator leg.

Environmental Control

Performance of the environmental control system was adequate. The primary water sublimator started three times and rejected heat loads which varied from 4700 to 8200 Btu/hr. Sublimator dryout followed predicted behavior.

The water and oxygen usages were within predicted limits. The average water consumption was approximately 6 lb/hr. The average oxygen usage was 0.27 lb/hr.

Cabin leakage was less than 0.1 lb/hr. The average cabin temperature for all three manned periods was $67° \pm 2°$ F.

FLIGHT CREW PERFORMANCE

Crew performance was excellent throughout the mission, and the flight was conducted essentially in accordance with the nominal plan.

Preparation for transfer to the lunar module required longer than anticipated, primarily because of the time required for the crewmen to don the space suits. The suit supply hoses were a source of interference and also contributed to the longer preparation time. As a result, about 1 hour was added to the preparation time for subsequent transfers.

Visual and photographic inspection of the entire spacecraft was accomplished after rendezvous and before docking.

BIOMEDICAL EVALUATION

The launch was postponed for 72 hours because of symptoms of upper respiratory infections in all three crewmen. Physical examinations 3 hours before launch revealed no infection.

The planned medical operations were conducted as scheduled except that the Lunar Module Pilot experienced some nausea and vomiting prior to and following the initial transfer to the lunar module.

Plans for extravehicular activity were modified because of the Lunar Module Pilot's illness. The physiological parameters were essentially normal throughout the mission. The Lunar Module Pilot's work rate during extravehicular activity was on the order of 500 Btu/hr.

MISSION SUPPORT PERFORMANCE

Flight Control

Flight control performance was satisfactory in providing operational support for the Apollo 9 mission. Minor spacecraft problems were encountered, but none was such that either the mission operations or the flight plan was significantly altered.

Early in the mission, a caution and warning light on hydrogen tank 1 was observed just prior to an automatic cycle of the heaters. This condition persisted and the crew had to be disturbed during a rest period at 81 hours to increase the hydrogen tank pressure.

On the third day, the crew were about 1 hour behind the timeline, resulting in cancelling all the planned communications tests except for the lunar module secondary S-band test and the lunar module two-way relay with television.

On the fourth day, the extravehicular activity was abbreviated and the external transfer from the lunar module to the command module was not performed. The activity was restricted to the lunar module forward platform because of concern about the Lunar Module Pilot's earlier illness and proper readiness for the rendezvous on the following day.

At approximately 78 hours, after the tunnel hardware had been installed, a crewman made an unplanned return to the lunar module to open a circuit breaker. This change impacted the rest period about 30 minutes.

Lunar module activation was performed approximately 40 minutes early on the day of rendezvous to insure an on-time rendezvous initiation. The lunar module tracking light was lost at staging, and the command module could not track the lunar module in darkness.

The lunar module VHF telemetry and S-band power amplifier were lost 6 and 12 hours, respectively, after the ascent firing to depletion. These failures were expected because of the lack of cooling. The electrical system capability for this spacecraft was several hours longer than predicted. Lunar module support terminated at 113:42:00.

On the sixth day, the sixth service propulsion maneuver was delayed by one revolution. The crew reported that the +X translation did not occur. A procedural error was made in loading the command module computer, since the proper service module reaction control system quads were not selected. The computer was reloaded, and one revolution later, the maneuver was made satisfactorily.

The command module telescope stuck several times at approximately 64 degrees. This problem required the crew to use a special tool to manually drive the telescope, but was of no significant impact to the mission.

The seventh service propulsion maneuver was increased to 25 seconds in duration to permit a test of the propellant utilization and gaging system.

Network

Overall mission support by the Mission Control Center and the Manned Space Flight Network was considered satisfactory throughout the mission. Mission Control Center hardware, communications, and computer systems experienced very few problems with no major data losses. Network telemetry, tracking, and command support were satisfactory. The few failures which were experienced had minimal impact on Mission Control Center operations. Carnarvon was the only site which had persistent support problems in that the command and telemetry computers experienced outages.

HF communications reception during some periods was marginal at several sites; however, the requirement for HF communications was kept at a minimum by using satellite communications systems when possible. Although several minor communications outages were experienced, no significant data losses were experienced. A number of significant problems were experienced with air-to-ground communications primarily because of ground procedural errors. During the fourth revolution, over Guaymas, air-to-ground voice was lost for approximately 6 minutes. This failure is attributed to a procedural error at the Mission Control Center, which had been improperly configured for the transmissions.

During extravehicular activity, air-to-ground transmissions to the spacecraft were lost from Guaymas, Texas, Merritt Island, Bermuda, and USNS Vanguard stations. Downlink voice was remoted to the Mission Control Center nominally during the same period. The loss of uplink capability was caused by a combination of the stations being configured to uplink S-band only, rather than S-band and VHF simultaneously, and the spacecraft crew had the S-band volume fully decreased as planned. The problem was further complicated by the inability to transmit VHF voice from Bermuda because of a simultaneous transmission on that frequency from the lunar module and a suppression of the VHF uplink by the continuously keyed portable life support system.

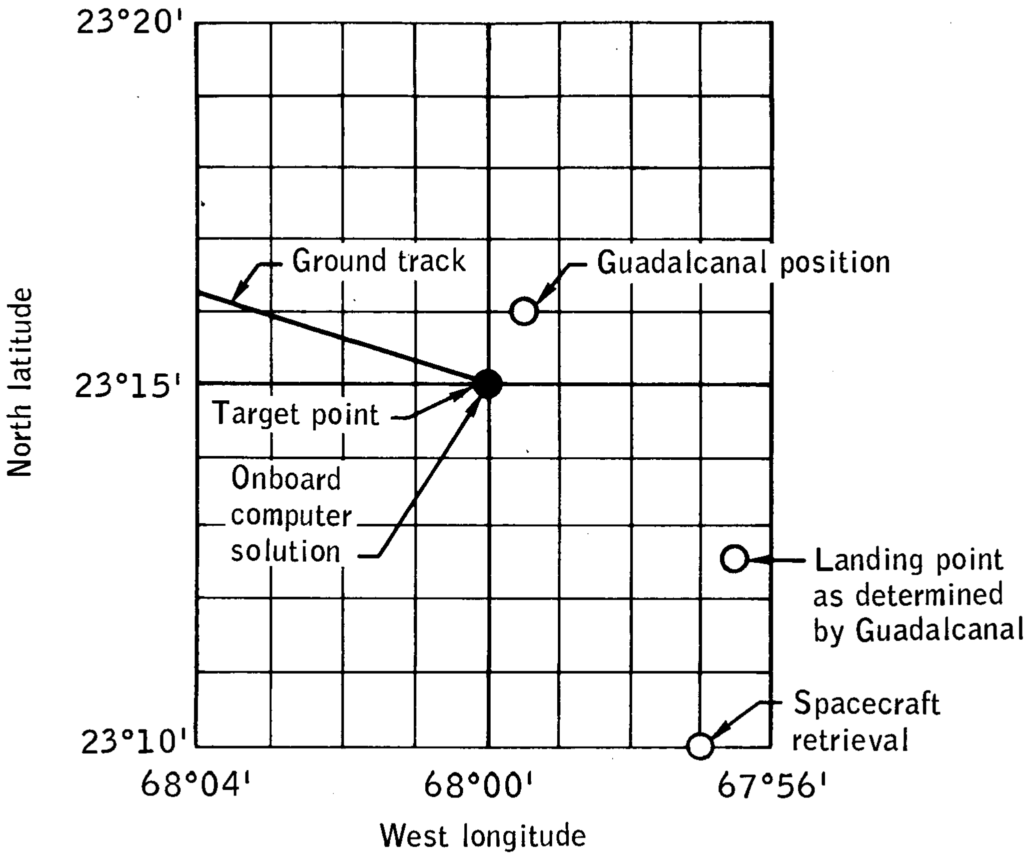
Air-to-ground communications were lost for approximately 3 minutes over Texas during revolution 119. This failure was attributed to a patching error at Texas.

Recovery

Recovery of the Apollo 9 spacecraft and crew was completed in the West Atlantic by the prime recovery ship, USS Guadalcanal. The following table is a list of significant recovery events on March 13, 1969.

Event	G.m.t., hr:min
First VHF contact	16:51
First beacon and voice contact	16:57
First visual contact	16:59
Landing	17:01
Swimmers deployed	17:07
Flotation collar installed	17:14
Command module hatch open	17:27
First astronaut aboard helicopter	17:39
All astronauts in helicopter	17:46
Astronauts on deck	17:50
Command module aboard recovery ship	19:13

The command module remained in the stable I flotation attitude. Sea-state conditions were very moderate at the recovery site. A preliminary plot of landing-point data is shown in the following figure.



Landing point data.

TABLE I.- SEQUENCE OF EVENTS

Event	Time, hr:min:sec
Launch Phase	
Range zero (16:00:00 G.m.t.)	
Lift-off	0:00:00.7
S-IC inboard engine cutoff	0:02:14.3
S-IC outboard engine cutoff	0:02:42.8
S-IC/S-II separation	0:02:43.4
S-II engine ignition commanded	0:02:44.2
Interstage jettison	0:03:13.5
Launch escape tower jettison	0:03:18.3
S-II engine cutoff	0:08:56.2
S-II/S-IVB separation	0:08:57.2
S-IVB engine ignition	0:09:00.4
S-IVB engine cutoff	0:11:04.7
Orbital Phase	
Orbital insertion	0:11:14.7
CSM/S-IVB separation command	2:40:50
Docking	3:02:08
Spacecraft ejection from S-IVB	4:08:05
First service propulsion maneuver	5:59:00
Second service propulsion maneuver	22:12:03
Third service propulsion maneuver	25:17:38
Fourth service propulsion maneuver	28:24:40
First descent propulsion maneuver	49:41:33
Fifth service propulsion maneuver	54:26:11
Lunar module hatch open for extravehicular activity	73:00:00
Lunar module hatch closed after extravehicular activity	73:49:00

TABLE I.- SEQUENCE OF EVENTS - Concluded

Event	Time, hr:min:sec
Orbital Phase - concluded	
First undocking	92:38:41
Command and service module/lunar module separation	93:02:53
Descent propulsion phasing maneuver	93:47:34
Descent propulsion insertion maneuver	95:39:07
Coelliptic sequence initiation maneuver	96:16:04
Constant delta height maneuver (first ascent propulsion)	96:58:14
Terminal phase initiation	97:57:59
Docking	99:03:00
Second undocking	101:22:44
Ascent propulsion firing to depletion	101:53:14
Sixth service propulsion maneuver	123:25:06
Seventh service propulsion maneuver	169:38:59
Eighth service propulsion maneuver (deorbit)	240:31:14
Entry Phase	
Command module/service module separation	240:36:10
Entry interface (400 000 feet altitude)	240:44:13
Begin blackout	240:47:00
End blackout	240:50:42
Drogue deployment	240:54:47
Main parachute deployment	240:55:34
Landing	241:00:53

TABLE II.- MANEUVER SUMMARY

Maneuver	Ignition, hr:min:sec	Firing time, sec	Velocity change, ft/sec	Resultant orbit			
				Apogee, n. mi.	Perigee, n. mi.	Period, min	Inclination, deg
First service propulsion	5:59:00	5.1	34.0	126.4	108.4	88.8	32.57
Second service propulsion	22:12:03	110.0	850.4	189.8	107.7	90.0	33.46
Third service propulsion	25:17:38	281.6	2567.6	271.8	109.4	91.6	33.82
Fourth service propulsion	28:24:40	28.2	300.5	271.5	109.3	91.6	33.82
First descent propulsion	49:41:33	369.7	1739.1	269.6	109.2	91.5	33.97
Fifth service propulsion	54:26:11	43.3	576.1	129.2	123.8	89.2	33.61
Command module/lunar module separation	93:02:53	10.9	5.0	127.2	121.8	89.1	33.62
Descent propulsion phasing maneuver	93:47:34	18.6	90.5	136.9	111.8	89.1	33.62
Descent propulsion insertion maneuver	95:39:07	24.9	43.1	138.9	134.0	89.6	33.62
Coelliptic sequence initiation	96:16:04	30.3	40.0	137.8	112.8	89.2	33.64
Constant delta height (first ascent propulsion)	96:58:14	2.9	41.5	116.4	111.9	88.8	33.64
Terminal phase initiation	97:57:59	34.7	22.3	125.7	112.6	(a)	(a)
Terminal phase finalize (braking)	(a)	(a)	(a)	126.6	121.7	89.1	33.63
Command module separation from ascent stage	101:32:44	7.2	3.0	127.3	121.4	89.1	33.63
Ascent propulsion firing to depletion	101:53:14	350.0	5391.0	3747.0	124.5	165.3	28.95
Sixth service propulsion	123:25:06	1.3	37.6	120.2	105.4	88.7	33.62
Seventh service propulsion	169:38:59	25.0	654.9	250.2	97.8	90.9	33.51
Eighth service propulsion	240:31:14	11.6	325.1	238.8	-4.2	90.8	33.52

[a]Sufficient data not available.